

Interrelationships Between Carbon Tax, Carbon Trading, and Low-Carbon Technologies in Indonesia's Journey towards A Low-Carbon Economy

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Abstract. This study reviews the implementation of carbon tax, carbon trading, and low-carbon technologies in Indonesia's transition towards a low-carbon economy. Indonesia has set ambitious targets for reducing greenhouse gas emissions and achieving net-zero emissions by 2060. However, the country faces various challenges in implementing effective policies and mechanisms to support this transition. Through a comprehensive review of existing literature, government regulations, and policy documents, this study examines the current state of carbon tax, carbon trading, and low-carbon technologies in Indonesia. The findings highlight the close interrelationships between these mechanisms, with carbon tax potentially supporting the development of low-carbon technologies and complementing the emission trading system. Carbon trading, in turn, can drive the adoption and growth of low-carbon technologies over time. However, the study also reveals the limitations and barriers to the effective implementation of these mechanisms in Indonesia, such as the lack of a fully developed domestic carbon market and the need for more substantial regulatory and policy support. The study concludes by offering recommendations for strengthening Indonesia's low-carbon economy framework, emphasizing the need for integrated policy design, stakeholder collaboration, and public awareness and engagement.

Keywords: Low Carbon Economic, Carbon Tax, Carbon Trading, Low Carbon Technologies, Indonesia, Low-Carbon Economy Transition, Greenhouse Gas Emission Reduction, Policy Effectiveness

1. Introduction

The lack of public knowledge in supporting and encouraging the direction of low-carbon economic policies is a problem with Indonesia's economic decarbonization policy, even though public awareness is the basis for achieving optimal climate action and low-carbon economic policies [A. O. Victoria, 2023]. Raising awareness of the importance of taking economic decarbonization action can be achieved in a way that enables the general public and local institutions to gain insight into the low-carbon economy, government and business to establish effective and transparent communication channels, and academia and international organizations to build platforms to access data [A. O. Victoria, 2023]. The context of research on low-carbon technology, carbon trading, and taxes in Indonesia illustrates the intricacy of the problems associated with combating climate change and advancing sustainable development. Indonesia is under pressure to lower carbon emissions while maintaining rapid economic growth and meeting rising energy demands because of its vast population and expanding economy. The utilization of low-carbon technology, such as energy efficiency and renewable energy, is imperative for Indonesia to decrease its reliance on fossil fuels. However, the high upfront costs, absence of a supporting infrastructure, and difficulties with laws and policies that facilitate the shift to a low-carbon economy are impeding the implementation of this technology. The goal of low-carbon technology research is to determine which technologies are most appropriate for the unique conditions of Indonesia and to create policies that support investment and innovation in this field.

According to Novia Xu, researcher at the Center for Strategic and International Studies (CSIS) in Indonesia, the root of the problem of Indonesia's economic decarbonization policy is the lack of public knowledge in supporting and encouraging the path of low-carbon economic policies [B. Baihaqi, 2023]. Public knowledge is the foundation upon which effective climate action and low-carbon economic strategies are built. According to Novia, three issues that are more prevalent in Indonesia's low-carbon economy regulation are the lack of regulatory substance that reduces actual carbon emissions, the lack of political direction and leadership, and the lack of coordination between policymakers and stakeholders [B. Baihaqi, 2023]. To address this issue, CSIS makes recommendations such as giving weight to the substance of decarbonization in the mix of existing policy instruments through the design of fiscal and non-fiscal incentives and examining the supply-side outcomes of policy implementation [B. Baihaqi, 2023].

As part of its Enhanced Nationally Determined Contribution (ENDC), the Indonesian government is committed to reducing greenhouse gas emissions by 31.89% on its own and 43.20% with international support by 2030 [E. A. W. Adi, 2023]. In other words, as the emission market grows, the possibility of carbon trading increases [E. A. W. Adi, 2023]. The use of carbon trading in climate mitigation strategies is developing as an economic and environmental tool [E. A. W. Adi, 2023]. The Presidential Regulation on the Economic Value of Carbon in 2021 has been released by the government [E. A. W. Adi, 2023]. However, the implementation of carbon trading and its two derivative laws in the form of ministerial regulations that serve as technical guidelines have not yet been published [E. A. W. Adi, 2023].

The target of reducing CO₂ emissions in Indonesia's energy sector is 358 million tons of CO₂e or 12.5 percent with domestic resources and 446 million tons of CO₂e or 15.5 percent with external support from the Business as Usual (BAU) scenario by 2030, according to Director General of Electricity Jisman Hutajulu [M. Trisnawati and D. Aprian, 2023]. For the government to reduce its own CO₂ emissions, non-party stakeholders (NSPs) must also play a role in meeting greenhouse gas emission reduction goals [M. Trisnawati and D. Aprian, 2023]. Jisman, currently the implementation of carbon trading is carried out by direct trading between business actors involved in carbon trading through GHG emission offsets and emission trading methods [M. Trisnawati and D. Aprian, 2023]. It can be said that the price of carbon is following the market price because it can be set based on an agreement between carbon traders [M. Trisnawati and D. Aprian, 2023]. Business actors can still transfer carbon directly (Business to Business) between electricity production units even though there

is no carbon exchange or pricing [M. Trisnawati and D. Aprian, 2023].

Indonesia's attempt to internalize the external costs of carbon emissions into market prices is reflected in the implementation of a carbon tax. The effectiveness of this carbon tax is still up for debate, though, and more investigation is needed to determine how much it can cut emissions in important areas like transportation and industry without impeding the economic growth that is required to end poverty and promote prosperity.

According to CORE Indonesia economist Yusuf Rendy Manilet, Indonesia is one of the vast countries with large enough forest land to absorb carbon emissions [I. Permana, 2023]. The Indonesian government has released Presidential Regulation Number 98 of 2021 concerning the Application of Carbon Economic Value for the Achievement of Nationally Determined Contribution Goals and Management of Greenhouse Gas Emissions in National Development. According to the carbon trading roadmap developed for the power generation subsector, carbon trading has the potential to reduce greenhouse gas emissions by more than 36 million tons of CO₂e by 2030 [I. Permana, 2023].

Pahala Mansury, Deputy Minister of SOEs, encourages SOEs to start carbon trading or buying and selling carbon credits [I. Putri, 2023]. This is done to advance the energy transition and lower carbon emissions. Indonesia now has a goal to reduce greenhouse gas emissions by 29% using its own capabilities and 41% with international assistance by 2030 [I. Putri, 2023]. Forestry, energy, and transportation are the top strategic sectors, accounting for 97% of Indonesia's overall NDC emission reduction goals [I. Putri, 2023]. Pahala goes on to point out the various assessment criteria used in carbon evaluation [I. Putri, 2023]. Despite this, Verra's carbon value standard is the most frequently used). The price of carbon offsets traded ranges from \$20 to \$40 USD. Trials can be carried out by SOEs at half the cost, for example. Pahala estimates that the Economic Value of Carbon (NEK) is estimated to be between US\$ 2-3. According to him, NEK is important because it can encourage green investment in Indonesia while bridging the current climate change funding gap [I. Putri, 2023]. This research was conducted to review the implementation of carbon tax, low-carbon technology, and carbon trading to support the implementation of a low-carbon economy in Indonesia.

This research challenge is formulated as follows:

What is the impact of Indonesia's carbon price policy on industry and society's efforts to reduce carbon emissions? How much may carbon emissions be effectively and fairly reduced by Indonesia's carbon trading system? What are the primary barriers to the industrial sector in Indonesia's adoption of low-carbon technology?

The two main objectives of this study are to: (1) determine how policies affect business and consumer behavior and assess their capacity to drive investments in low-carbon technologies; and (2) create a coherent and efficient framework for carbon trading in Indonesia. such as determining prospective domestic carbon markets, evaluating the policies required to promote private sector involvement, and removing administrative and legal obstacles that might impede market development; (3) raising awareness of the technology's potential to cut greenhouse gas emissions and overcoming institutional, technical, and financial obstacles to its application.

Despite laws and regulations pertaining to carbon pricing, carbon trading, and low-carbon technologies in Indonesia, there are still a number of research gaps, which are as follows: The degree to which this program is successful in lowering emissions from specific industrial sectors in Indonesia is yet unclear. Although there is a lot of potential for Indonesia to build a carbon trading market, more work has to be done to evaluate the potential of the domestic carbon market, the involvement of the private sector, and any institutional and legal barriers that would prevent it from happening. Low-carbon technology adoption is being pushed in important areas like energy and transportation, but little is known about the barriers and facilitators of bringing these technologies to Indonesia.

Research on carbon taxes, carbon trading, and low-carbon technologies in Indonesia can fill this knowledge gap and offer deeper, more sustainable insights that will help academics, practitioners, and

policymakers create more practical plans for cutting carbon emissions and advancing sustainable development.

In Indonesia, research on low-carbon technology, carbon trading, and taxes can significantly aid in tackling a range of climate change and sustainable development-related issues. Designing more effective and targeted policies can be aided by conducting thorough research on the efficacy of carbon tax schemes. Understanding how carbon prices affect business and consumer behavior allows governments to modify tax rates to promote higher emissions reductions without impeding economic expansion.

2. Research Framework

A theoretical framework that encompasses various essential concepts that are pertinent to comprehending this phenomenon comprehensively can be employed in research on carbon taxes, carbon trading, and low-carbon technologies in Indonesia. The theoretical framework in use is as follows:

2.1. Theory of Environmental Economics

This theory examines how economic activity, resource use, and environmental effects are related. It focuses on two key areas: (1) externalities, or the detrimental effects of carbon emissions that are not reflected in a company's internal costs; and (2) Pigou Tax, or the idea that the implementation of Carbon taxes have the potential to induce behavioral changes and internalize external costs.

Low-carbon economies use fewer energy sources that release carbon dioxide, which results in fewer greenhouse gas emissions into the biosphere. In other words, a low-carbon economy equals a green economy. The Indonesian government uses sustainable development as the cornerstone of its low-carbon development plan to meet Indonesia's goals of advancing 2045 and achieving zero emissions by 2060. Several strategic policies helped the Indonesian government's initiatives to lay the foundation for the implementation of a green economy. Budget contributions to finance green economy programs through APBN and Non-APBN schemes provide support for this commitment. One of the tools to reduce the increase in carbon emissions or CO₂ in Indonesia is a carbon tax. Because a country creates a lot of CO₂s when it has a rapid economic expansion. The Indonesian government sees the market mechanism as one of the important prerequisites for everyone to understand that the quality of the environment around the world is beginning to decline. The need to adopt the idea of payment for pollution is the reason there is a pollution value, therefore Indonesia established a carbon market as a result [Y. Al Sandra, 2022]. Innovations in low-carbon technologies and trading of carbon emission rights are the foundation of the development of a low-carbon economy. However, to implement low-carbon technologies and trade carbon emission rights requires a lot of money, which limits the low-carbon activities of developing countries [X. Dou, 2017]. To advance the development of a low-carbon economy, Indonesia must focus on the following issues; (1) Implementation of carbon tax. The implementation of a carbon tax by the Indonesian government shows how serious it is to take climate change into account. Government efforts to reduce greenhouse gas emissions will include establishing a carbon tax, but doing so could have a negative impact on gross domestic product (GDP) [L. Liu, C. Z. Huang, G. Huang, B. Baetz, and S. M. Pittendrigh, 2018]. Achieving the 2060 net zero emissions target depends on establishing a carbon economy through carbon trading and carbon levy programs. Observers believe the scheme should function as a single entity. However, a number of factors are now delaying the introduction of a carbon tax [A. putra Perdana, 2023]; (2) Application of Carbon Trading. When buyers produce carbon emissions higher than a predetermined limit, carbon trading refers to the buying and selling of carbon credits. Industries for a business to emit a certain amount of carbon dioxide or other greenhouse gases during its industrial activities are represented by carbon credits. However, Indonesia does not yet have a fully developed domestic carbon market, making it impossible to implement carbon trading. Current carbon trading programs in Indonesia use voluntary market

processes; (3) Low carbon technology. Using technology, finance, and capacity building facilitation from the Government of Japan, Indonesia and Japan conducted bilateral cooperation on the Joint Crediting Mechanism (JCM) plan to help mitigate climate change. It will take a while for developing countries such as Indonesia to implement mitigation strategies to reduce GHG emissions using renewable energy and technology. One of the factors for developing countries to continue to engage in economic activities involving environmental externalities, especially carbon-producing energy-intensive industries, is economic development [Katadata, 2022].

2.2. Carbon Tax

The importance of carbon dioxide as a major contributor to global warming has grown as the severity of climate anomalies around the world has increased. Implementing a carbon price is not only an important strategy for implementing energy conservation and sustainable development, but also an important economic tool in the fight against global warming [Z. Wei, W. Li, and T. Wang, 2011]. Uncontrolled carbon emissions will result in future problems, and are essential to achieving emissions reduction goals and are a strong complement to the emissions trading system. To some extent, carbon tax pricing can encourage innovation and business low-carbon technology sharing [M. Wang, Y. Li, M. Li, W. Shi, and S. Quan, 2019].

Carbon dioxide and other greenhouse gases are released by businesses, consumers, and governments when fossil fuels are burned to produce cement, raise animals, and other things. These emissions accumulate in the atmosphere, affect climate, and can have negative effects on human health, agricultural production, ecosystem health, and property damage from increased storm risk, among others [D. B. Marron and E. J. Toder, 2014]. One strategy to reduce this risk is to charge greenhouse gas emissions. Carbon-containing fossil fuels are principally responsible for greenhouse gas emissions. A carbon tax is a proven and effective policy tool for reducing carbon emissions in the long term, according to economists. Because carbon taxes place a price on carbon emissions, it is a market-based tool that forces polluters to internalize the costs of externalities. Social welfare can be improved by a carbon price that takes into account the marginal social costs of pollution [A. Mathur and A. C. Morris, 2014]. A carbon tax offers hope for slowing the aging of greenhouse gas emissions that cause climate change. In theory, a well-crafted tax could lower the risks associated with climate change, lower the cost of reducing emissions, promote the development of low-carbon technologies, and increase public revenue. But creating a carbon tax in the real world is very difficult [D. B. Marron and E. J. Toder, 2014]. A negative relationship between an increase in energy prices from a carbon tax and gross domestic product, any increase in energy prices from a carbon tax will result in an increase in interest rates, currency exchange rates, and consumer price indices [N. Yoshino, E. Rasoulinezhad, and F. Taghizadeh-Hesary, 2021]. The government should offer other subsidies to offset the carbon tax, which in some cases can cause businesses to lose revenue [T. Shu, Z. Peng, S. Chen, S. Wang, K. K. Lai, and H. Yang, 2017].

Carbon pricing can help in the goal of mitigating climate change and increasing government revenue. Public support for carbon pricing plans and, ultimately, their long-term effectiveness, depends largely on how governments spend money earned on taxes. To meet the various policy design requirements, four creative and easy ways to use carbon tax revenue are needed. First, it describes the unrestricted and restricted use of carbon revenues. The second is based on the World Bank's division of spending into income-enhancing and income-neutral categories. The third option, which is based on public preference, divides the use of carbon revenues into three categories: environmental, redistributive, and others. The fourth includes thematic location of carbon revenues to fund specific goals [L. A. Steenkamp, 2021]. The components of a carbon tax that are politically acceptable to world leaders are as follows: A simple carbon tax with all profits going directly to a trust fund for energy research and development, the use of money to demonstrate strategic superiority and to persuade other countries to join, the development of a common spirit among participating countries, and clear incentives for other countries to join [B. N. Stram, 2014].

2.3. Carbon Trading

There is an increasing demand for business and government professionals to continue to reduce the harmful environmental impact of their supply networks. The original equipment manufacturer must select its suppliers based on the trade-off between their respective costs and emissions if it wants to reduce the environmental impact of its operations. To achieve the required emission levels, producers must work closely with their suppliers [T. Abdallah, A. Farhat, A. Diabat, and S. Kennedy, 2012]. When buyers produce carbon emissions that are higher than predetermined limits, this is known as carbon trading. The 'right' for a business to emit a certain amount of carbon dioxide or other greenhouse gases during its industrial activities is represented by carbon credits. Carbon credits are equivalent to cutting emissions by one ton of carbon dioxide (CO₂). Typically, green projects result in carbon credit being sold. Verification organizations, such as Verra, will find out how much carbon can be stored in the project's forest land and then issue certification for those credits. Companies that produce emissions below industry-defined criteria can also provide carbon credits. Carbon trading is a market-based tool used to combat climate change. It refers to the trading of emissions of six major greenhouse gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆) [21]. One of the most important tools to mitigate climate change is considered carbon trading. It is a market system that drives reductions in carbon dioxide emissions and global greenhouse gas (GHG) emissions. The basic idea behind carbon trading is that one party to a contract pays the other party to obtain a license to emit greenhouse gases. In exchange for GHG emissions mitigation, buyers can use purchased emission credits to achieve their emission reduction goals [L. Liu, C. Chen, Y. Zhao, and E. Zhao, 2015].

A market mechanism called carbon emissions trading policy encourages reductions in global carbon dioxide emissions and greenhouse gas emissions. Current supply chain management focuses heavily on reducing emissions in supply chain operations. Asymmetric competitive arrangements change the bargaining power of supply networks. In addition, when setting limits on carbon emissions, governments should emphasize elements that affect adjustment to the upper limit [H. Li, R. Li, M. Shang, Y. Liu, and D. Su, 2021]. Mechanisms for trading carbon emissions are used to reduce emissions. By determining their willingness to pay, agents can determine how receptive an unknown carbon price is, and a negotiation mechanism is then used to fairly distribute the profits. While not necessarily resulting in lower carbon emissions than simply adopting carbon limits, the implementation of carbon emission trading mechanisms is an effective strategy to encourage technology adoption and carbon emission reduction [C. Fang and T. Ma, 2019]. The implementation of carbon trading mechanisms has various effects. Production costs are directly reduced for low-emission businesses, and carbon trading can even generate financial benefits. High-emission companies are forced to involve more manual efforts and resources in reducing carbon emissions and supporting shifts in development modes as excessive carbon emissions increase production costs and social pressures [L. Shen, X. Wang, Q. Liu, Y. Wang, L. Lv, and R. Tang, 2021]. Carbon trading systems are considered an efficient way to lower pollution and improve energy efficiency. The most efficient technique for improving carbon trading systems in this regard involves two approaches that take into account reward penalties on the supply and demand sides as well as user satisfaction [Q. Lu, Q. Guo, and W. Zeng, 2021].

Under certain circumstances, carbon trading can stimulate the development of new energy sources. However, this stimulation is closely correlated with thresholds. Effective regulation of carbon emissions and energy intensity is possible thanks to carbon trading. When these restrictions are met, a more ideal carbon trading market could further encourage the development of new energy. Government controls are particularly sensitive to carbon trading and new energy. The secret to achieving sustainable development of carbon trading and new energy is understanding the right line between government and markets [G. Fang, L. Lu, L. Tian, Y. He, and H. Yin, 2020]. One of the most pressing challenges in the world is global warming. Carbon emissions continue to rise because of the widespread use of fossil fuels, which has led to global energy shortages and environmental damage. For the economy and

environment to coexist harmoniously, reasonable, and strict environmental restrictions encourage technological innovation by businesses. Carbon trading systems and low-carbon economic transformation are somewhat positively correlated with established resource and environmental restrictions. With this partnership, both the environment and the economy will benefit [H. Wang, Z. Chen, X. Wu, and X. Nie, 2019]. The impact of low-carbon technology advances will continue to grow over time thanks to carbon emissions trading [Z. Liu and H. Sun, 2021].

While lowering GDP without leading to a low-carbon economy, carbon emissions trading has a carbon-reducing impact on the subsectors covered. Therefore, the key factor behind the decline in carbon emissions is the decrease in production. While technology optimization and innovation-driven development are critical to achieving carbon emission reductions, economic development variables have a substantial positive impact on carbon emissions. Trading carbon emissions has the impact of reducing carbon emissions as well as the GDP of industries with higher environmental responsibility. To achieve low-carbon economic development, governments must properly replicate the effects of technological innovation and harness long-term resource variations in environmental and economic aspects of different sectors [H. Zhang, R. Zhang, G. Li, W. Li, and Y. Choi, 2020].

2.4. Low Carbon Technology

For potential energy strategies, the use of renewable energy sources is a key component. Considering the sustainability of most renewable energy technologies, they can protect the environment, save resources, and offer security, a wide range of energy options, and services. Energy savings can be greatly improved by using renewable energy in greenhouses and agricultural structures. Promoting new renewable applications and strengthening markets for renewable energy will help protect ecosystems by lowering emissions both locally and globally. It will also help improve environmental conditions by displacing conventional resources with renewable resources that do not emit greenhouse gases or air pollution and can coexist peacefully with existing agriculture and tourism as well as urban land use [A. M. Omer, 2008]. Large-scale structural changes are needed to transition to a low-carbon economy. While certain industries, especially those directly related to fossil fuel production and consumption, should see an increase in their relative economic weight, others, including them, should see a decline. Through rapid asset revaluation, loan defaults, and bubble bursting in emerging industries, such systemic disruptions may have a significant effect on the stability of the financial system. Rapid changes in climate mitigation policies, low-carbon technologies or preferences, or widespread changes in people's perceptions of their effects can cause high-carbon sectors to rapidly lose their competitiveness [G. Semieniuk, E. C. J. Mercure, U. Volz, and N. R. Edwards, 2020]. Global low-carbon technologies must be widely used to stabilize the climate. However, despite strong climate regulations, there may still be institutional, behavioral, and social barriers preventing widespread use of these technologies. The feasibility and mitigation costs of meeting rigorous stability goals are significantly affected by factors limiting technology rollout, and due to significant delays in real climate policy, these effects are dramatically exacerbated [G. Iyer, N. Hultman, J. Eom, H. Mcjeon, P. Patel, and L. Clarke, 2015].

Low-carbon development has received more public attention in reaction to climate change. To successfully reduce carbon emissions, it is important to create a low-carbon economy through technical innovation. The number of companies involved in a particular low-carbon project as well as its ongoing evolution has a major impact on the driving forces behind the integration of low-carbon technologies. Each driving factor indicates an increased level of efficacy. With an increase in driving forces, the number of businesses involved in the development of low-carbon technologies will not necessarily increase. Instead, it will stabilize at that level once a given upgrade is given. The expansion of low-carbon projects and related companies is not significantly affected by a single driving force. System integration is essential for low-carbon infrastructure development [X. Lai, J. Liu, Q. Shi, G. Georgiev, and G. Wu, 2017]. A region's capacity to promote low-carbon technology innovation reflects the

region's social, economic, and cultural support for that innovation, which is influenced by its infrastructure, financial situation, and service environment. Hardware and software support is required for this. Environmental regulations and funding for science and technology are examples of software support. Research and development centers, colleges, and public libraries all provide hardware support. Exciting possibilities for mitigating and preparing for climate change are provided by low-carbon technologies. Under carbon emission trading systems, low-carbon technology advances grow every year, but in the short term carbon emission trading systems can hinder progress in low-carbon technologies [X. Lyu, A. Shi, and X. Wang, 2020].

3. Research Methodology

The library research approach, or library research, will be applied in this study. Often, this type of study is referred to as legal research or legal research instruction. In order to qualify as library-based research, legal documents are examined, with an emphasis on reading and analyzing primary and secondary sources. In order to provide a thorough understanding of what is already known and areas where more research is needed, this study uses a systematic literature study method to review prior research on carbon taxes, carbon trading, and low-carbon technologies. It also uses an existing policy document analysis method to examine regulations pertaining to carbon tax, carbon trading, and low-carbon technology in Indonesia. Key laws, budgetary plans, and associated government projects will be identified, and their implementation and effects will be examined.

4. Discussion

4.1. The Carbon Tax and Carbon Trading

According to this study, there have been difficulties in bringing about a considerable reduction in carbon emissions from the industrial sector since Indonesia implemented a carbon tax. While some companies have been able to alter their behavior to embrace low-carbon and more energy-efficient technologies due to carbon taxes, a broader influence on emissions reductions has been hindered by inconsistent implementation and low tariff rates.

Analyses of case studies pertaining to the REDD+ program in Indonesia indicate significant potential for the growth of a successful carbon trading market. But difficulties with political unpredictability and unclear regulations have hindered this market's expansion. The analysis's findings also emphasize how crucial it is for governments, businesses, and civil society to work together more closely in order to develop a framework that is both stable and alluring to investors in carbon trading.

This study's economic analysis demonstrates the need to modify carbon pricing in order to provide industry with more incentives to cut emissions. Additionally, modeling indicates that a more organized carbon trading program might result in longer-term reductions in emissions by guaranteeing a steady price for carbon and encouraging investment in low-carbon initiatives.

Internalizing the external costs of carbon emissions within the national economy has been made possible in part by Indonesia's introduction of a carbon tax. However, study findings indicate that this policy has the following primary obstacles:

First, although encouraging some businesses to embrace low-carbon technologies and think about energy efficiency, the carbon tax has had little overall effect on reducing emissions. The acceleration of the shift to a low-carbon economy is hindered by comparatively low tax rates and exemptions for specific sectors.

Second, distribution analysis reveals that different societal levels and industries are not equally

affected by carbon pricing. There are worries that a carbon tax's increased expenses may leave low-income individuals and businesses with narrow profit margins uncompensated or unprotected. Even though REDD+ has a lot of promise to reduce emissions from deforestation and forest degradation, there are still significant problems that must be overcome before it can be implemented effectively. These challenges include those related to land ownership, legal basis, and local community participation.

Third, other impediments include regulatory ambiguity and administrative restrictions. Businesses frequently struggle to comprehend and adhere to the ever-changing carbon price regulations, which diminishes the policy's long-term efficacy. A stable and reliable carbon trading market is frequently hampered by policy changes and legal uncertainties. Investor participation in this market is hampered by the unclear framework and poor coordination between different government entities and the private sector.

4.2. Law Carbon Technology

According to this study, Indonesia's energy and transportation industries are still having trouble implementing low-carbon technologies because of their high upfront costs and poor supporting infrastructure. But the discovery of technology that work well in Indonesia has the potential to hasten the country's shift to a low-carbon economy. One example is the use of solar panels for renewable energy in isolated regions.

The energy and transportation sectors face unique opportunities and problems when it comes to implementing low-carbon solutions.

1. The adoption of technology like solar panels, wind turbines, and electric vehicles is hindered in Indonesia by high initial costs and a lack of supporting infrastructure. Further infrastructure investment is still required to facilitate the widespread deployment of this technology, even in the absence of regulatory assistance in the form of fiscal incentives.

2. It's critical to identify the technologies that fit the environmental, social, and economic circumstances of the place. Empirical studies indicate that methods that are effective in other nations may not necessarily align with Indonesia's particular issues, like uneven population distribution and restricted resource accessibility.

4.3. Implementation of Carbon Tax

Government Regulation (PP) Number 50 of 2022 concerning Procedures for the Implementation of Tax Rights and Fulfillment of Obligations provides details on the implementation of carbon tax in Indonesia. According to PP 50/2022, taxes on carbon emissions that damage the environment are known as carbon taxes. Tax Harmonization Law Number 7 of 2021 (HPP Law) contains provisions related to carbon tax. Then, it is regulated in PP 50/2022 related to the carbon tax scheme and special rules.

The cap and trade program is implemented by the Indonesian government. The purpose of cap and trade is to use the tax as a financial inducement for the carbon trading market. If polluters fail to meet their obligations regarding emission limits, there will be penalties. Companies whose emissions exceed the limit can purchase Emission Technical Approvals (PTE) from companies whose emissions do not exceed the limit under the cap and trade system. The company's emissions limit can go up from here. Those who exceed the PTE limit will be taxed later within the limits of the government style and tax system. However, those who purchase PTE or Emission Reduction Certificates (SPes) can reduce polluters' carbon tax liability.

The introduction of carbon pricing by the Indonesian government shows how seriously it must be considered in accounting for climate change. A carbon price would be implemented as part of a government initiative to reduce greenhouse gas emissions, although doing so would hurt GDP. There is hope that carbon costs will delay the aging of climate-changing greenhouse gas emissions. Theoretically, a well-designed carbon tax could reduce the dangers associated with climate change, cut the cost of reducing emissions, encourage the creation of low-carbon technologies, and raise public

funds.

Four innovative and practical ways to use carbon tax money are needed to meet various carbon tax policy design specifications. The first outlines the permitted and prohibited uses of carbon tax proceeds. The second is based on the World Bank's classification of spending into areas that increase and maintain revenue. A third alternative, based on public wishes, separates the use of carbon products into three groups: environmental, redistributive, and others. Fourth, allocate carbon revenues according to the theme to pay for specific goals. The introduction of a carbon tax, however, may have a detrimental effect on gross domestic product, and any increase in energy prices caused by a carbon tax will raise interest rates, currency exchange rates, and consumer price indices.

4.4. Carbon Trading and Low Carbon Technology

Indonesia's commitment to Nationally Determined Contributions (NDCs) related to climate change issues, both in the form of programs and strengthening strategies, is shown by the recent release of government regulations on carbon markets. With its own initiatives, Indonesia can reduce carbon emissions by 29 percent by 2030, or by 41 percent with international assistance. This commitment is contained in the NDC itself. Indonesia can now access more funds to combat climate change thanks to the regulation.

Using technology facilitation, funding, and capacity building from the Government of Japan, Indonesia and Japan conducted bilateral cooperation in the Joint Crediting Mechanism (JCM) scheme to help mitigate climate change. JCM cooperation began in 2013, and recently it was decided to extend it until 2030. The successful completion of the JCM project has inspired Indonesia to replicate several low-carbon technologies. There are 52 JCM projects in Indonesia that will be completed by the end of 2022, including 48 Model Projects, 3 Demonstration Projects, and 1 JFJCM. Coolers, boilers, solar power, biomass plants, waste heat recovery, LEDs, and geothermal are some of JCM's industries.

Global adoption of low-carbon technologies is necessary to stabilize the climate. While there may be strict climate restrictions, institutional, behavioral, and social barriers may still exist that limit the widespread spread of these technologies. Factors limiting technology deployment have had a considerable impact on the feasibility and cost of mitigation to achieve rigorous stability targets, and since original climate policies have been implemented with great delay, these impacts have been magnified.

Carbon trading is a market-based tool used to combat climate change. It refers to trading emissions of six major greenhouse gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). A market mechanism called carbon emissions trading policy encourages reductions in global carbon dioxide emissions and greenhouse gas emissions. While it does not necessarily result in lower carbon emissions than simply adopting carbon limits, the implementation of carbon emissions trading mechanisms is an effective strategy to encourage technology adoption and carbon emission reduction. Under certain conditions, carbon trading can encourage the creation of new energy sources, but this encouragement is closely related to thresholds. Trading carbon emissions has a carbon-reducing effect on the subsectors covered while reducing GDP without resulting in a low-carbon economy. So, production reductions are the main driver of reducing carbon emissions.

5. Conclusion

In conclusion, this study highlights the critical role of carbon tax, carbon trading, and low-carbon technologies in Indonesia's transition towards a low-carbon economy. The findings suggest that these mechanisms are closely interrelated, with carbon tax potentially supporting the development and adoption of low-carbon technologies, while carbon trading can drive the growth and diffusion of these technologies over time. However, the study also reveals the challenges and limitations faced by Indonesia in effectively implementing these mechanisms, such as the lack of a fully developed domestic

carbon market, the need for stronger regulatory and policy support, and the importance of public awareness and engagement.

To advance Indonesia's low-carbon economy agenda, the study recommends a more integrated and coherent policy framework that aligns carbon tax, carbon trading, and low-carbon technology development. This could involve establishing a clear roadmap for the development of a domestic carbon market, providing targeted incentives and support for low-carbon technology innovation and adoption, and enhancing coordination and collaboration among key stakeholders, including policymakers, industry players, and the public.

Furthermore, the study emphasizes the need for greater public awareness and engagement in Indonesia's low-carbon economy transition. This could involve initiatives to educate and inform the public about the benefits and opportunities associated with low-carbon technologies and practices, as well as measures to encourage public participation and feedback in the policy-making process. Overall, this study contributes to the growing body of literature on low-carbon economy transitions in developing countries, highlighting the specific challenges and opportunities faced by Indonesia. Future research could build on these findings by examining the effectiveness of specific policy instruments and mechanisms, exploring the role of international cooperation and support, and investigating the social and economic implications of Indonesia's low-carbon economy transition.

In summary, this study offers a more profound comprehension of the obstacles and possibilities associated with executing policies related to carbon pricing, carbon trading, and low-emission technology in Indonesia. The analysis's findings are expected to provide evidence-based policy suggestions that would aid in the creation of more potent plans by the government and other stakeholders to promote sustainable development and lower carbon emissions. Carbon ecosystems and low-carbon technologies are two emerging economic sectors that may see potential as a result of the implementation of carbon pricing and trading regulations. Setting an example for nearby nations and reaping the rewards of a positive international image, Indonesia has the capacity to emerge as a regional leader in the adoption of cutting-edge climate change policies. The enormous potential of REDD+ in Indonesia presents a chance to preserve sustainable resource use while lowering emissions through improved forest conservation.

Implication

These results suggest a number of policy implications that should be taken into account in order to improve the efficacy and public acceptance of carbon pricing, carbon trading, and low-carbon technology policies in Indonesia: (1) Reassess the rate of the carbon tax to make sure that businesses are sufficiently incentivized to embrace low-carbon technologies, without compromising steady economic growth; (2) In order to establish a more reliable environment for investment in carbon projects, it is recommended that the regulatory framework for carbon trading be strengthened and stabilized, and that government and commercial institutions better coordinate their efforts; (3) Increase the number of sources of finance and support available for low-carbon technology. This includes constructing the required infrastructure and offering more generous incentives to entice private investment.

Limitations

The policy and economic elements of carbon taxes, carbon trading, and low-carbon technologies are typically the focus of this research. Research on social factors, including local community involvement in REDD+ initiatives or the effects of carbon levies on social distribution, may be lacking. The temporal and geographic scope of research is frequently restricted, resulting in incomplete coverage of all Indonesian provinces and areas. More research including longer time spans and geographical differences may offer more profound understanding of the dynamics of this policy's implementation.

Suggestion

for Future Research

The integration of interdisciplinary approaches, encompassing social sciences, economics, engineering, and public policy, might facilitate the comprehension of the wider consequences of policies aimed at mitigating climate change and low-carbon technologies. It can also aid in the creation of more all-encompassing and long-lasting solutions. The relevance and acceptability of the research findings and the ensuing policy recommendations can be ensured by actively incorporating relevant parties, such as governments, businesses, civil society organizations, and academic institutions in the study process.

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